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Investigating patterns of transmission with historical source material

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1. Background

Multiple waves of cholera devastated European cities during the 19th century. In 1853 a singular nation-wide epidemic hit the fully susceptible population of Denmark. This was just 1 year after a trade quarantine on ships was lifted for commercial reasons.

Vast amounts of published and un-published source material remains in archives today, allowing for very detailed analysis of epidemic cholera in a historical, immunologically naive population.

A better understanding of cholera transmission is needed to parameterize mathematical models for investigating the effect of intervention programs like vaccination. Understanding the relative importance of short- versus long cycle transmission could inform public health response to contemporary epidemics.

2. Aim

To identify the modes of cholera transmission within and between urban centers in 19th-century Denmark.

To evaluate the potential of historical material, both published and unpublished, to inform epidemiological models and on-going global health response to cholera outbreaks in low income settings.

Figure 1 (below). Reconstructed transmission chains

From physicians' narratives we collected information on the first generations of cholera cases in a new setting. From this we reconstructed several early-epidemic transmission chains.

The typical index case was a sea or land traveller that infected family or care takers upon arrival.

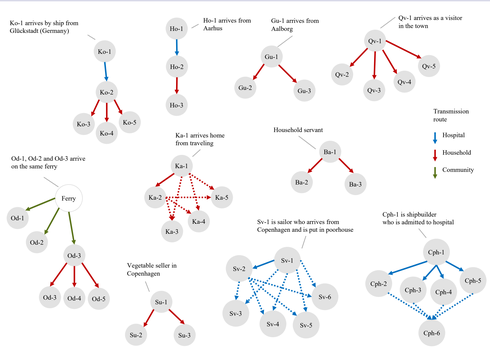

Figure 2 (above). Deaths from cholera in northern Zealand

Based on yearly reports from parish vicars we are in the process of mapping every cholera death in Denmark in 1853.

3. Data & methods

We accessed individual-level data on cholera morbidity and mortality from town physicians, along with population data from census records. We also accessed parish-level rural mortality data, collected by church vicars, for high resolution data on the geographical diffusion of cholera in Denmark.

Furthermore, we examined physicians' narratives in official reports to reconstruct several first and second generation transmission chains.

4. Results

Most of Denmark's cholera cases were urban dwellers. It is clear from figure 2, however, that some rural districts were hit by disease as well, especially those surrounding Copenhagen (south-west corner, c. 138,000 pop. and 4600 deaths from cholera in 1853).

A notable case is Amager (soouth of Copenhagen) whose farmers took frequent trips to the city. Furthermore much of the city's fecal waste was spread on their crops as fertilizer.

From collected early-epidemic transmission chains we computed the serival interval (3 days) and R_0 (c. 1.5-2.0).

The spatial and temporal data strongly suggest human-to-human transmission in the first generations of spread. The cases we found were travellers, by land or sea, that brought disease with them from an infected setting.

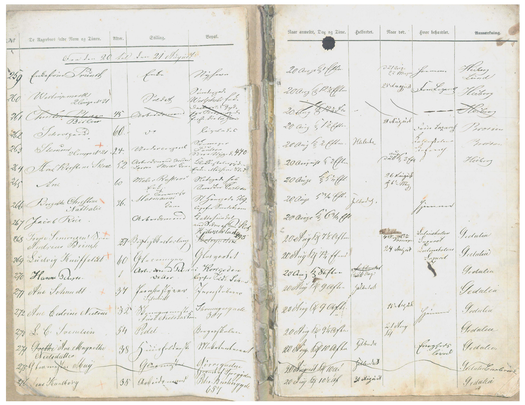

Figure 3 (above). Original protocol from Aalborg in 1853

A medical protocol, written by physicians during the cholera epidemic in Aalborg (c. 7700 pop. in 1853), is kept at the Danish National Archive. It is a running list of every known cholera case along with their name, adress, occupation, age, sex, as well as dates of symptom onset and death or recovery.

With this high resolution data - almost complete for the Aalborg epidemic - we will be able to model the spatio-temporal transmission of unmitigated cholera and further explore case clustering on a household-level.

5. Conclusions

For study the case of Denmark 1853 is unique, as registration of cholera was unusually thorough, and the dominating medical theory had authorities discard restraining measures such as quarantine. Historical material is a valuable, and to some degree neglected, asset in epidemiological research. Highly detailed records, such as our material, can help decipher transmission routs and delude important parameter values for mathematical models of cholera.

We have found that short-cycle, human-to-human transmission plays an important role in the early phase of a cholera epidemic.

As the historical case definition of cholera stressed both rice water diarrhea and severe dehydration, only a fraction of the sick were recorded. In a pre-sanitation setting such as Denmark 1853, epidemics lasted 6-10 weeks in smaller towns. In a major city like Copenhagen individual neighbourhoods displayed a similar pattern.